feet. The Upper Peninsula is a region notorious for its much lower gradient. The author discusses the various hypothesis framed to account for the differences in the gradient. Among these are the cooling action of Lake Superior, a survival of the Ice Age coldness, and differences in the conductivity of rocks. The author favours the last hypothesis.—Production of X rays by a battery current, by J. Trowbridge. The installation of a plant of 20,000 storage cells at the Jefferson Physical Laboratory has enabled the author to obtain X-rays of exceptional brilliancy, yielding negatives of great contrast. When the X-ray tube is first connected with the battery terminals no current flows. It is necessary to heat the tube, when it suddenly lights up. A distilled-water resistance of about 4,000,000 ohms is inserted in the circuit.

Annalen der Physik, No. 5.—Change of conductivity of gases by a continuous electric current, by J. Stark. The resistance of a gas conveying an electric current is highest near the electrodes, owing to the accumulation of ions of the same sign in this neighbourhood. It has another maximum near the middle, but rather more towards the side of the anode. The resistance is influenced by the heat developed at the electrodes, by the kathode rays, and by the unequal speed at which the two kinds of ions travel through the gas.—Objective presentation of the properties of polarised light, by N. Umow. A beam of parallel plane-polarised light is allowed to fall on various geometrical bodies whose surfaces have peculiar optical properties, such as a cone covered with fuchsine, a quartz plate, or a Babinet compensator. The reflection or transmission of the light gives rise to striking colour phenomena. Peculiar spiral effects are obtained by sending the beam through an opalescent colophonium emulsion.—Magnetic screening, by H. du Bois and A. P. Wills. In this portion of their work, the authors calculate and verify the effect of a triple screen of iron for galvanometers. The external diameters of the three screens are 2·5, 4·3 and 8·0 cm. respectively, and their thicknesses are 0·27, 0·18 and 0·18 cm. The total theoretical "screening ratio," *i.e.* the ratio by which the disturbing magnetic field is reduced, is 60·2, and the observed ratio is 64·6.—Armoured galvanometers, by H. du Bois and H. Rubens. Describes some galvanometers screened in accordance with the results of the previous paper.—Rotating magnetic flag, by G. Jaumann. A small magnet mounted like a flag on a glass rod as an axis may be given a continuous rotation by immersing it in mercury contained in a glass vessel surrounded by a tight-fitting copper vessel, with a current traversing the body of the mercury and returning through the copper vessel. The work spent in overcoming the resistance of the mercury is derived from the current itself. It appears as a counter E.M.F. until the mercury rotates with the magnet.—Thermal deformation of balances, by T. Middel. Delicate balances show a considerable change of sensitiveness with the temperature. The author shows that this is due to the bending of the beam of the balance, owing to the unequal expansion of the upper and the lower portion, and that is due to the unequal working of the metal, the coefficient of expansion for cast brass being less than that of rolled brass.—The additive character of atomic heats, by S. Meyer. The author shows that in the case of twenty-six oxides an excess of the sum of atomic volumes over the molecular volume is accompanied by an excess of the aggregate atomic heats over the molecular heat, and that a defect of atomic volumes is accompanied by a defect of atomic heats in the same manner. Boron and bismuth sesquioxides are the only exceptions.

Bulletin de l'Académie des Sciences de St. Pétersbourg, vol. viii. No. 1.—Yearly report of the Academy.—A newly-discovered Old Turkish inscription, by Dr. W. Radloff, preliminary report. The inscription was discovered by Madame Elizabeth Clements near Urga, and excellent reproductions of it were made. Dr. Radloff found that it was made in honour of the wise Toyukuk, father-in-law of Bilga-khagan, who was born in 646 of our era.—On the elements of earth-magnetism at Kamenets, Khotin and Odessa, by W. Dubinsky.

Vol. viii. No. 2.—On the rapid motion of the line of the absides in the system of α' Gimini, by A. Byelopolsky.—On the spectroscopic determination of the movements of γ Virginis, by the same.—Aurora borealis observed at Pavlovsk on December 20, 1897, by V. Kuznetsoff, with two photographs.—Hydrobiological researches at the Sebastopol Biological Station, by A. Ostroumoff.

Vol. viii. No. 3.—On the attempts at reproducing cometary phenomena by means of experiments, by Th. Bredikhin (in Russian). The recent results obtained by photography permitted us to obtain most exact reproductions of cometary forms. They stimulated the desire of producing theories of comets, and, as far as the author knows, five different theories were proposed lately; they differ essentially in their fundamental principles. No great comets having appeared lately, the earlier drawings, made by previous astronomers, necessarily must be taken into account. Bredikhin found it necessary, therefore, to systematically discuss the facts which relate to the variety of forms of comets, and the passages from the one form to another. These facts can be ignored by no theory, and the author consequently analyses those criteria which must be applied to each theory of the comets.—On the way of building magnetic observatories, by H. Wild.—Description of a very rare case of *Craniopagus parietalis*, by J. Ziematzky (plate).—On the influence of the terms of third order in the perturbations function of the movement of the earth round its centre of gravity on the formulæ of nutation, by A. Ivanof (in French). The author gives a new formula for reducing the length of the second pendulum for any geocentric latitude.

Vol. viii. No. 4.—Ephemerid of the comet of Encke from June 1 to July 31, 1898, by A. Ivanoff.—On the differences of the horizontal intensities of earth magnetism obtained from observations of the unifilar and the bifilar theodolite, by H. Wild.—Positions of 1041 stars of the star-cluster 5 Messier, deduced from photographs, by Madame Shilow. Full list, compiled from careful measurements made on photographic plates.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 31.—"The Crystalline Structure of Metals." Second Paper. By Prof. J. A. Ewing, F.R.S., and Walter Rosenhain, B.A.

The investigations described in this paper deal principally with the phenomena of annealing. The first section of the paper describes experiments made in the hope of observing under the microscope the process of recrystallisation in strained iron. This attempt to watch the process of recrystallisation failed, although the experimental difficulties of keeping a specimen under microscopic observation while it was being heated were successfully overcome. The specimen was electrically heated in a vessel with a thin glass or mica window, and the microscope-objective was kept cool by directing a strong blast of cold air on it and on the surface of the window.

The next section of the paper deals with the changes of crystalline structure which go on in lead and other metals at comparatively low temperatures. The authors' attention was directed to this by noticing that a piece of plumber's sheet lead, when etched with dilute nitric acid, exhibits a strikingly crystalline structure, with large crystals. The character of this appearance led the authors to the view that a slow process of annealing or recrystallisation was at work in such lead at ordinary atmospheric temperatures, and the authors have satisfied themselves that this is the case. The method of investigation consisted in taking a series of micro-photographs, at low magnifications, of certain marked areas in the surface of a specimen, in order to watch the change which went on through lapse of time, or after application of some thermal treatment.

When a piece of cast lead is severely strained by compression, the originally large crystals, after being considerably flattened, are driven into and through one another, so that the etched surface of a strained specimen presents a fine grain, whose crystalline nature only becomes apparent under considerable magnification (80 to 100 diameters). A piece of lead severely strained in this way, and kept for nearly six months in an ordinary room without any special thermal treatment, was found to be undergoing continuous change during that time. A series of photographs of this specimen, taken at intervals during the six months, show that a great number of the small crystals have grown larger at the expense of their neighbours. In similar specimens which have been kept at 200° C., the growth has been much more rapid and more pronounced. The rate of growth is a function of time and temperature, but some specimens show much more rapid changes than others under similar conditions of temperature; in some cases five minutes' exposure to a temperature of 200° C. is sufficient to alter the

crystalline pattern completely. Experiments have also been made at 100° C. and 150° C., leading to the general result that crystalline growth will occur at any temperature from that of an ordinary room, *i.e.* 15° C. or 20° C., up to the melting point of lead, and that in general the higher the temperature the more rapid is the initial rate of change. No numerical data can be given, as the crystals are quite irregular, both in size and shape.

A comparison of micro-photographs of the same specimen at various stages reveals the fact that the growth of an individual crystal occurs, not in uniform layers all round it, but by the formation of arms and branches that invade the neighbouring crystals, the intervening portions sometimes changing at a later stage. This action is analogous to the formation of skeleton crystals in a metal during solidification from the liquid state, the space between the branches filling in as solidification proceeds.

A marked feature observed in several specimens was the large and rapid growth of one or two individual crystals; in several instances such individua s grew until they were some hundreds of times larger than their neighbours. Generally the most aggressive crystals were found near the edges of the specimen. It is noticeable that at times a crystal which has already grown considerably is swallowed up by a more powerful neighbour.

Some light is thrown on the nature of these actions by the fact that this growth only occurs in crystals that have been subjected to severe plastic strain. By casting the metal in a chill mould, specimens of lead can be obtained having a crystalline structure quite as minute as that found in a severely strained specimen, but this structure remains unchanged at temperatures which produce rapid change in a strained specimen.

The investigation of the effects of such comparatively moderate temperatures was extended to other metals, viz. tin, zinc and cadmium. In tin, the various phenomena of crystallisation from the fluid state are strikingly illustrated on a large scale by the thin layer of that metal which constitutes the surface of commercial tin-plate. The effects of rapid and slow solidification in producing small or large crystals respectively are well marked, and an examination of the etched surface of tin-plate under the microscope reveals beautiful geometrical markings or pits, whose oriented facets produce the well-known selective effect of oblique illumination. The study of the crystalline structure affords an explanation of the nature and method of production of patterns in "moirée métallique," a process which has long been in use for the decoration of articles manufactured of tin-plate.

The final section of the paper deals with an hypothesis, which is advanced as an attempt to explain the mechanism of the growth of crystals in apparently solid metal.[1] According to this hypothesis, the metallic impurities which are present in a metal play an important part in the action. When a metal solidifies from the fluid state, the metallic impurities ultimately crystallise as a film of eutectic alloy in the inter-crystalline junctions; when fairly large quantities of such eutectics are present, the microscope reveals their presence as an inter-crystalline cement, such as that formed by "pearlite" in slowly cooled mild steel; very minute quantities of eutectic, however, will be invisible and yet capable of forming a thin film of fusible cement. The authors conceive that the changes of crystalline structure which go on while the piece is in the solid state are accomplished by the agency of eutectic films between the crystals, in dissolving metal from the surfaces of some crystals and depositing it on others. When a metal is severely strained, these films of eutectic will be also strained and in many places broken, thus allowing the actual crystals to come into contact with one another. The difference in the rate of etching of adjacent crystals and the phenomena of the electrolytic transfer, in an acid solution, of lead from one crystal to another in the same mass of metal, support the supposition that there is a difference of electric potential between the crystal faces which are brought into contact by severe strain. If it be assumed that a film of eutectic alloy when fluid, or even when in the pasty condition that precedes fusion, can act as an electrolyte, we may regard any two crystals thus in contact, with a film of eutectic interposed in places, as a very low resistance circuit, and the growth of the positive crystal at the expense of the negative would result. Moreover, such growth would be more rapid at higher temperatures, and its rate at a given temperature would vary in different specimens according to the nature and quantity of the impurities present. That an alloy can act as an electrolyte has not been established experimentally, but the assumption is supported by the close general analogy between alloys and salt solutions. This analogy extends to the very question of the growth of crystals, as Joly has shown that when crystals of a salt are immersed in their mother-liquor, growth of one at the expense of others will take place.

It should be added that solution of one crystal into the intervening film of eutectic, along with deposit on the neighbouring crystal from the eutectic, may occur as a consequence of differences of orientation, producing differences of "solution pressure" apart from actual electrolysis, but the fact that growth has not been observed to occur except in strained crystals favours the view that the action is electrolytic.

Some further results which have been deduced from the above hypothesis have been verified by experiment. It follows from the hypothesis that an inter-crystalline boundary containing no eutectic would be an impassible barrier to crystalline growth, but if the eutectic could in any way be supplied, growth across the boundary might take place. In an absolutely pure specimen of lead, there would be no eutectic at the inter-crystalline junctions, but as extremely minute traces of impurity would suffice to set up the action, it is almost hopeless to verify the hypothesis in this way. Some experiments on the cold welding of lead have, however, borne out these conclusions. Two clean, freshly-scraped lead surfaces will unite under great pressure in the cold state, and if a piece so welded be annealed, the crystalline growth due to the annealing, with very rare exceptions, never crosses the inter-crystalline boundary formed by the welding surface. To test whether the presence of some eutectic would allow growth to take place, small quantities of a more fusible metal were scattered over the freshly-scraped surfaces of lead before squeezing them together. Then, after a cold weld had been made by pressure, on annealing by exposure to 200° C. it was found that crystal growths frequently crossed the line of the weld, as the above theory led one to expect. This experiment has been repeated many times with the uniform result that whenever a small quantity of eutectic, or of an impurity capable of forming a eutectic with the lead, was scattered over the clean surfaces before welding, a distinct growth of crystals across the boundary took place as a result of annealing. On the other hand, a large number of welds were made without introducing any impurity, and with very rare exceptions they showed no growth across the boundary, even after the annealing process was continued for some weeks. In rare exceptions a minute amount of growth across the boundary was observed, but these may fairly be accounted for by the almost unavoidable presence of traces of impurity. The result as a whole goes far to confirm this solution theory of crystalline growth in annealing.

June 14.—"Static Diffusion of Gases and Liquids in Relation to the Assimilation of Carbon, and Translocation in Plants." By Horace T. Brown, F.R.S., LL.D., and F. Escombe, B.Sc., F.L.S.

This paper is intended to be the first of a series descriptive of the work carried out by the authors in the Jodrell laboratory on the fixation of carbon by green plants, and deals mainly with the purely physical processes by which atmospheric carbon dioxide gains access to the active centres of assimilation.

The new evidence which F. F. Blackman brought forward in 1895 in favour of the gaseous exchanges of leaves taking place exclusively through the stomatic openings, presents at first sight certain difficulties of a physical nature, which have led to an examination of the whole question of the free diffusion of carbon dioxide at very low tension, and under a set of conditions very different from those under which the previous determinations of the coefficient of diffusion of carbon dioxide and air have been made by Loschmidt and others, where the gases were initially of equal tension, and the ratios of mixture departed widely from those of ordinary atmospheric air. The inquiry has led to the discovery of some new facts connected with the static diffusion of gases and liquids, which are of considerable interest, not only from the physical point of view, but from the explanations they suggest of certain natural processes which are primarily dependent on diffusivity.

The method employed in the first instance for the determination of the diffusivity of atmospheric carbon dioxide was one of *static diffusion* down a column of air of a definite length towards an absorptive surface at the bottom of the column When a static condition has been established, there is a steady flux of the carbon dioxide down the air column

[1] It is proper to say that this hypothesis is due to Mr. Rosenhain.—J. A. E.

which may be quantitatively investigated by the same simple mathematical treatment as the "flow" of heat in a bar when the permanent state has been reached, or the "flow" of electricity between any two regions of a conductor maintained at a constant difference of potential.

By a long series of experiments of this nature it was found that the diffusivity constant, k, for very dilute CO_2 does not materially depart from the value assigned to it by Loschmidt and others, when experimenting with much higher ratios of mixture, and that the difference is certainly not of sufficient magnitude to be taken into serious account in the study of the natural processes of gaseous exchange in the assimilating organs of plants.

In the static diffusion of a gas, vapour, or solute, as the case may be, the amount of substance diffusing in a given time, all other conditions being the same, is directly proportional to the sectional area of the column. It is found, however, that if the flow is partially obstructed by interposing at any point in the line of flow a thin septum pierced with a circular aperture, the rate of flow across unit area of the aperture is greater than it would be across an equal area of the unobstructed cross-section of the column at this point. If the margin around the aperture has a width of at least three or four times its diameter, the rate of flow is now found to be directly proportional to the *linear dimensions* of the aperture and not to its area, so that the velocity of flow through unit area varies inversely as the diameter.

A large number of experiments on the diffusion of carbon dioxide, water-vapour and sodium chloride in solution are given in support of this proposition. All these show that the rate of diffusion across such a septum, all other conditions being the same, is directly proportional to the diameter of the aperture, and not, as might have been expected, to its area.

Exactly the same result is obtained when small circular discs of an absorbent, such as a solution of caustic alkali, are surrounded by a wide rim and exposed to *perfectly still* air, the amount of carbon dioxide absorbed under these conditions being proportional to the *diameters* of the discs.

If, however, there are any sensible air currents the absorption becomes proportional to the areas.

These two sets of phenomena may be explained as follows:—

In the case of the absorbing disc in perfectly still air, the convergent streams of carbon dioxide creep through the air towards the absorbing disc, establishing a steady gradient af density, and this creep will be a flux perpendicular to the lines of equal density, which form curved surfaces or "shells" surrounding the disc and terminating in the rim. The state of things is exactly analogous to the electric field in the neighbourhood of a conductor of the same shape and dimensions as the absorbent disc.[1] In the case of the gas, the curves or "shells" of equal density are the analogues of the similarly curved surfaces of equipotential above the electrified disc, whilst the converging lines of creep or flux of the gas are the analogues of the lines or tubes of force which bend round into the disc as they approach it.

If we consider two such absorbent discs of different diameters, the curved surfaces in each system corresponding to a given density will be found at actual distances from the discs which are in the same proportion to each other as are the diameters of the discs. In other words, the gradient of density on which the rate of flow depends will be proportional to the diameters of the discs, which is exactly what is found experimentally.

This case of an absorbent disc is the exact converse of one which has been theoretically investigated by Stefan, viz. the conditions of evaporation of a liquid from a circular surface. He found that the lines of flux of the vapour proceeding from the surface of the liquid must be hyperbolas, whilst the curved surfaces of equal pressure of the vapour must form an orthogonal system of ellipsoids, having their foci, like the hyperbolas, in the bounding edges of the disc. This was a purely mathematical deduction which has never been verified experimentally, but it will be seen that the exactly converse phenomena of diffusion are in complete agreement with it.

In the other case of a diffusive flow through a circular aperture in a diaphragm, the lines of flow, which are *convergent* as they approach the aperture, bend round their foci situated in the edges of the disc and form a *divergent* system on the other side. If the chamber into which they pass is a perfectly absorbent one, and is sufficiently large, there will be formed on the inner side of the diaphragm a system of density shells similar to those outside, but with the gradient of density centrifugally instead of centripetally arranged. This system of shells is termed negative, and is as effective as the outer positive system in regulating the flow according to the "diameter law," so that this law will still hold good even if the outer air currents are sufficient to sweep away the external positive shells altogether.

All the known facts of diffusion through circular apertures in a diaphragm are in complete accord with the above explanation, which is fully elaborated in the original paper.

By diffusing colouring matter through apertures in a septum, under such conditions as to prevent convection currents, the "density shells" have been rendered visible, and it has been shown that their ellipsoidal form is exactly that which is demanded by the above hypothesis. Moreover, this method gives an experimental demonstration of the more rapid projection of the diffusing particles from the edges of the aperture than from a point nearer its centre, a fact completely in harmony with the deduction of Stefan regarding the evaporation of liquids under analogous conditions.

The various cases which present themselves in practice with regard to the rate of diffusion through single apertures in a diaphragm are then discussed from the above point of view, and simple formulæ for the determination of this rate for single and double systems of density shells are established: (1) for cases where the thickness of the diaphragm is negligible, and (2) for other cases where the apertures become more or less tubular. In a subsequent section of the paper it is shown how closely the observed facts conform to these deductions, and that in static diffusion through apertures in a septum we have a new and accurate method for the determination of the diffusivity constants of atmospheric CO_2, of the vapours of liquids, and of substances in a state of solution.

Since the velocity of the diffusive flow through unit area of an aperture in a diaphragm varies inversely with the diameter, it might reasonably be expected that a diaphragm could be so perforated with a series of very small holes arranged at suitable distances from each other, as to exercise little or no sensible obstruction when it was interposed in a line of diffusive flow, although the aggregate area of the small holes might represent only a small fraction of the total area of the septum. Multiperforate diaphragms of this kind were found to possess all the remarkable properties which had been anticipated.

The material used for the septa was very thin celluloid, which was perforated at regular intervals with holes of about 0·38 mm. in diameter. Details of a number of experiments with such diaphragms are given, in which it is shown that they may be so arranged as to produce but little obstructive influence on the diffusive flow of a gas when the total area of the apertures amounts only to about 10 per cent. of the area of the septum, and that nearly 40 per cent. of the full diffusive flow may be maintained when the number of the apertures is so far reduced as to represent an area of only 1·25 per cent. of the full area of the septum.

The explanation is to be found in the local intensification of the gradient of density in the immediate neighbourhood of the diaphragm, and which does not extend to the column away from the apertures. This disturbance of gradient is brought about by the rapid convergence of the lines of flux, and their divergence on the other side, with the consequent formation of a system of "density shells" over each aperture. A system of perforations of this kind may be compared with a system of conductors electrified to a common potential, the density of the diffusing substance above the apertures corresponding to electric potential, and the non-absorbing portions of the diaphragm to a surface formed by lines of electric force. Just as the electric capacity of a plate is not much reduced by cutting most of it away, so also is it possible to block out a large portion of the cross-section of the diffusing column without materially altering the general static conditions on which the flow depends.

The importance of these results in relation to diffusion through porous septa is next considered, diffusion through a thin porous septum being only an extreme case of free diffusion through a multiperforate diaphragm, whose apertures are so far reduced in size as to materially interfere with the mass movement of the diffusing substance.

A section of the paper is devoted to the application of these new observations to the processes of gaseous and liquid diffu

[1] The authors are indebted to Dr. Larmor for this suggestion of the electrostatic analogy.

sion in living plants, and it is pointed out that the structure of a typical herbaceous leaf illustrates in a striking manner all the physical properties of a multiperforate septum. Regarded from this point of view it is shown that the stomatic openings and their adjuncts constitute even a more perfect piece of mechanism than is required for the supply of carbon dioxide for the physiological needs of the plant, and instead of expressing surprise at the comparatively large amount of the gas which an assimilating leaf can take in from the air, we must in future rather wonder that the intake is not greater than it actually is.

From data afforded by actual measurements of the various parts of the stomatal apparatus of the sunflower it is shown that an extremely small difference of tension of the carbon dioxide within the leaf, as compared with that in the outer air, will produce a gradient sufficient to account for the observed intake during the most active assimilation.

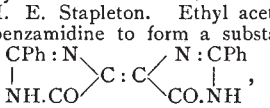
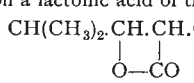
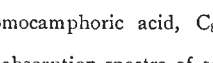
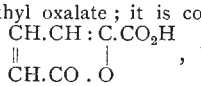
It is also shown that the large amounts of water-vapour which pass out of the leaf by transpiration are well within the limits of diffusion, and that it is unnecessary to assume anything like mass movement in the outcoming vapour.

The translocation of solid material from cell to cell in the living plant is next considered, especially with reference to this transference being, at any rate in part, brought about by means of the minute openings in the cell-walls through which the connecting threads of protoplasm pass. Notwithstanding the very small relative sectional area of these perforations they probably exercise an important function in cell-to-cell diffusion, in virtue of their properties as multiperforate septa.

There are two appendices to the paper, one in which a full description is given of a series of experiments on the absorption of carbon dioxide by solutions of caustic alkali from air in movement; the second being devoted to a detailed description of the methods used for accurately determining the carbon dioxide absorbed.

Physical Society, June 22.—Mr. T. H. Blakesley, Vice-President, in the chair.—A paper, entitled "Notes on Gas Thermometry," by Dr. P. Chappuis, was read by Dr. Harker. The author having been led to recognise that hydrogen could not be used as a thermometric substance at high temperatures, on account of its action on the walls of the glass reservoirs, has had recourse to a constant volume nitrogen thermometer with an initial pressure slightly under 800 mm. The value of the coefficient of expansion of nitrogen at constant volume is variable, diminishing up to 80° C. and then increasing slightly. In fact, nitrogen at 100° C. behaves like hydrogen at the ordinary temperatures, its compressibility being less than that required by Boyle's law. A table of corrections was therefore prepared. The readings of the constant volume nitrogen thermometer are too low, but the corrections are small, amounting to about 0·04° C. at the temperature of boiling sulphur. The mean result of the author's experiments for the boiling point of sulphur is 445°·2 under a pressure of 760 mm. Callendar and Griffiths' results obtained with a constant pressure air thermometer is 444°·53. The difference is attributed to the joint action of several causes:—(1) The corrections for a constant pressure thermometer are about double those of a constant volume instrument. This correction applied to Callendar and Griffiths' result would raise it about 0·1°. (2) Callendar and Griffiths have used a value for the gas constant which is larger than that obtained by more recent experiments. Adopting the latter value, the boiling point would be raised to 445°. (3) The divergence may be due to the expansion of the reservoir. The most accurate way of determining this is by the interference method of Fizeau. This method is used with small pieces of the material, and the author has employed it to determine the coefficient of expansion between 0° and 100°. Extrapolation to 450° might cause errors The linear expansion has recently been determined by Bedford between 0° and 840° by a comparator method. The homogeneity of porcelain is doubtful, especially when glazed, and the great differences occurring between the expansions obtained from the above methods is attributed to the change in form of the tube in Bedford's experiments, brought about by unequal thickness and want of homogeneity and consequent unequal expansion. The author therefore adheres to his value of the boiling point obtained from the expansion by the Fizeau method, whilst recognising the uncertainty attaching to the application of the coefficient of expansion of the reservoir over an interval four times as great as that over which it was determined.—A paper on a comparison of impure platinum thermometers, by Mr. H. M. Tory, was read by Prof. Callendar. The object of this paper is to investigate the probable order of accuracy attainable in the determination of high temperatures by the use of ordinary commercial specimens of platinum wire. Five wires were compared, from 400° to 1000° C. The fundamental coefficients of the wires varied within 40 per cent. of the maximum value, but the temperatures observed by them when calculated on the platinum scale by means of the ordinary simple formula, did not differ by more than 9° at 1000° C. Each wire was directly compared with a pure standard wire, the two being wound side by side in the same tube. Curves have been drawn with the platinum temperatures of the standard wire as abscissæ, and the differences between the temperatures indicated by the two wires compared as ordinates. These curves are all straight lines, within the limits of observation, and hence the determination of two constants is sufficient to enable us to compare an impure platinum thermometer with the standard, and therefore with the scale of the gas thermometer. The two constants can at once be obtained from observations at the boiling point of sulphur and the freezing point of silver, and thus a practical thermometric scale can be established, which between 0° and 1000° never differs by more than two or three degrees from the gas scale.—Prof. Callendar said he was unable to agree with the correction to his observations suggested by M. P. Chappuis. He considered that the uncertainty in the coefficient of expansion of the gas was due to uncertain changes in the volume of the bulb, and to uncertainty in the coefficient of expansion of mercury. The fundamental coefficient of mercury was ·00018153 according to Regnault, ·00018216 according to the later reduction of Broch, and ·00018256 according to experiments by Chappuis with a hard glass bulb. It made a difference of no less than 4 per cent. in the fundamental coefficient of expansion of the glass, according as the original results of Regnault, or the value found by Chappuis, assuming the linear expansion of the glass, were adopted. The importance of the changes in the volume of the bulb had been fully pointed out, and a method of taking approximate account of these changes had been explained in the paper on the boiling point of sulphur in 1890. Unfortunately the glass employed was rather soft, and the changes of volume which occurred were too great to permit of the most accurate determination of the coefficient. The boiling point, when corrected for the smaller expansion of the bulb, came out lower than 444·53°. With regard to porcelain, Prof. Callendar did not consider it a good material, on account of the glaze. He did not think that the average coefficient of a tube or bulb over a large range of temperature could be inferred from a small and possibly asymmetric specimen. The results might be less inconsistent in the case of homogeneous and well-annealed metallic bulbs. The correction for the expansion of the bulb was, he believed, given by the expression $dt = (C + b\theta)t(t - 100)$. He did not agree with M. P. Chappuis that the correction was independent of c, although the value of b was certainly most important at high temperatures. He also wished to take exception to the method adopted by Chappuis of calculating the correction of the nitrogen thermometer. According to Joule and Thomson, the correction should be greater; according to other authorities, it might be less. He hoped to discuss this in a further communication to the Society. Mr. Glazebrook said that, although he placed confidence in Chappuis' formula for a definite piece of porcelain between certain temperatures, he thought further and careful work was necessary before fixing on a formula for ordinary use. Prof. Carhart said he would like to see a comparison made between the results of experiments with gas thermometers and those with platinum and platinum-rhodium couples. Mr. Rose-Innes expressed his interest in the behaviour of nitrogen about 100° C., as mentioned in M. P. Chappuis' paper. Dr. Lehfeldt said the peculiarities of the nitrogen scale between 70° and 80° might be explained by the reversal of the properties of nitrogen between 0° and 100°.—A paper on the law of Cailletet and Mathias and the critical density was read by Prof. S. Young. The law of Cailletet and Mathias is very nearly, though in most cases not absolutely, true. It appears to be only strictly true when the ratio of the actual to the theoretical density at the critical point has the normal value 3·77. The curvature of the "diameter" is generally smaller the nearer this ratio approaches its normal value. The curvature is in nearly every case in opposite directions, according as this ratio is greater or less than 3·77. The curvature is generally so slight that the critical density may be calculated from the mean densities of liquid and saturated vapour at

temperatures from about the boiling point to within a few degrees of the critical point with an error generally not exceeding 1 per cent. If, however, the critical density is calculated from the mean densities at low temperatures, the error may be considerable; in the case of normal decane it is between 5 and 6 per cent. The law does not, as a rule, hold good at all for substances the molecules of which differ in complexity in the gaseous and liquid states. Mr. Rose-Innes said that in his paper the author had used the generalisations of Van der Waals, although the author himself had shown that they were not strictly true. Prof. Young said that the generalisations held in some cases, although they did not in others. In all cases they were approximately true, and it was therefore advisable to use them, and study the results as far as possible.—The Society then adjourned until next October.

Chemical Society, June 7.—Prof. Thorpe, President, in the chair.—The following papers were read.—Condensation of ethyl acetylenedicarboxylate with bases and β-ketonic esters, by S. Ruhemann and H. E. Stapleton. Ethyl acetylenedicarboxylate reacts with benzamidine to form a substance of the probable constitution,  , which the authors term glyoxaline red.—Condensation of phenols with ethyl phenylpropiolate, by S. Ruhemann and F. Beddow. Sodium phenoxide reacts with ethyl phenylpropiolate, yielding a substance of the constitution $C_6H_5.C(OC_6H_5):CH.CO_2Et$; this ester is easily hydrolysed, and the acid readily loses carbon dioxide, giving phenoxystyrene, $CH_2:C(OC_6H_5).C_6H_5$.—The constitution of pilocarpine, by H. A. D. Jowett. Isopilocarpine yields on oxidation a lactonic acid of the constitution  ; the alkaloid also contains the groups :NH and $:NCH_3$.—The nitrogen chlorides derivable from metachloroacetanilide and their transformations, by F. D. Chattaway, K. J. P. Orton and W. H. Hurtley.—The persulphuric acids, by T. M. Lowry and J. H. West. A quantitative study of the equilibrium established between sulphuric acid, hydrogen peroxide and "persulphuric acid" on mixing the former two substances, affords evidence indicating the existence of the acids $H_2O_2.4SO_3$ and $H_2O_2.2SO_3$ in a mixture of sulphuric acid and hydrogen peroxide.—On diphenyl- and dialphyl ethylenediamines, their nitro-derivates, nitrates and mercurichlorides, by W. S. Mills.—Derivatives of cyanocamphor and homocamphoric acid, by A. Lapworth. The halogen derivatives of cyanocamphor are reduced to cyanocamphor and homocamphoramic acid, $C_8H_{14}(CO_2H).CH_2.CONH_2$, by strong aqueous alkalis. α-Bromo-homocamphoric acid, $C_8H_{14}(CO_2H).CHBr.CO_2H$, made by heating homocamphoric dichloride with bromine, can be converted into homocamphoric acid,  .—The ultra-violet absorption spectra of some closed chain carbon compounds. II. Dimethylpyrazine, hexamethylene and tetrahydrobenzene, by W. N. Hartley and J. J. Dobbie.—A study of the absorption spectra of *o*-oxycarbanil and its alkyl derivatives in relation to tautomerism, by W. N. Hartley, J. J. Dobbie and P. G. Paliatseas.—Action of formaldehyde on amines of the naphthalene series (II.), by G. T. Morgan. The action of formaldehyde on ethyl-β-naphthylamine in cold acetic acid solution results in the formation of 2:2-diethyldiamino-1:1-dinaphthylmethane.—The bromination of benzeneazophenol (II.), by J. T. Hewitt and W. G. Aston.—Condensation of ethyl crotonate with ethyl oxalate, by A. Lapworth. Ethyl γ-oxalocrotonate, $CO_2Et.CO.CH_2.CH:CH.CO_2Et$, is formed by the action of sodium ethoxide on a mixture of ethyl crotonate and ethyl oxalate; it is converted into α-pyrone-α′-carboxylic acid,  , by hydrochloric acid.—Researches in silicon compounds. VI. On silicodiphenyldiimide and silicotriphenylguanidine, by J. E. Reynolds. On heating silicophenylamide, $Si(NHC_6H_5)_4$, the diimide, $Si(NC_6H_5)_2$, and silicotriphenylguanidine, $Si(NC_6H_5)(NHC_6H_5)_2$, are obtained.—Note on Bach's hydrogen tetroxide, by H. E. Armstrong.

Linnean Society, June 7.—Prof. Sydney H. Vines, F.R.S., President, in the chair.—Mr. R. Morton Middleton exhibited a letter, dated "London, 13 June 1788," in the handwriting of Sir J. E. Smith, addressed to Charles Louis L'Héritier, at Paris, in which he mentioned a visit to Oxford with Sir Joseph Banks and J. Dryander for the purpose of looking over the plants and drawings of Sibthorp, who was then lecturing there; and added some critical remarks on several species of *Sida* which L'Héritier had sent him for determination. Mr. Middleton also exhibited an engraved portrait of Sir J. E. Smith from the *Gentleman's Magazine*, 1828, which, with the letter, he presented to the Society.—Mr. F. Enock, with the aid of the lantern, exhibited several photomicrographs and photographs of living insects, and gave an illustrated account of the life-history and metamorphoses of a dragonfly (*Æschna cyanea*).—Mr. E. S. Goodrich read a paper, entitled "Notes on *Syllis vivipara*, Krohn." This worm, which he found in a tank at the Naples Laboratory, appeared to be identical with that described by Krohn in 1869 (*Arch. f. Naturg.* xxxv. p. 197), and in general form resembled Claparède's *Syllis Armandi* (probably *S. prolifera*, Krohn). The peculiar point of interest was its method of reproduction, the embryos growing within the body-cavity of the parent to an advanced stage (when they resemble the adult except in their smaller size and fewer segments), and escaping by the breaking off of the posterior portion of the parent's body.—Dr. Otto Stapf read a paper on the two Melastomaceous genera *Dicellandra*, Hook. f., and *Phaeoneuron*, Gilg. He showed that the differences between them are not in the heterandry and homœandry respectively, as was supposed, but in much more important characters which concern all those parts which affect the formation of the fruits and seeds. The diagnoses of the two genera must therefore be revised, with the result that *Phaeoneuron* and *Dicellandra* change their character as monotypic genera.—A paper was read by Miss A. L. Embleton giving a full account of the anatomy and histology of *Echiurus unicinctus*, received from Prof. K. Mitsukuri, of Tokyo.

CAMBRIDGE.

Philosophical Society, May 7.—Prof. Clifford Allbutt, F.R.S., in the chair.—Exhibition of anomalous bones from predynastic Egyptian skeletons, by Prof. Macalister, F.R.S.—Ammocoetes a Cephalaspid, by Dr. Gaskell, F.R.S. The paper contained evidence that Ammocoetes was the living representative of the ancient Cephalaspids.—Note on some abnormalities of the limbs and tail of Dipnoan fishes, by H. H. Brindley. *Lepidosiren* and *Protopterus* sometimes exhibit partial bifidity of the limbs and tail. This condition of the limbs of *Protopterus* has received some speculative attention, and it has also been suggested that a branched limb of *Lepidosiren* might have a respiratory function. Boulenger and Howes have since shown that *Protopterus* may regenerate its limb in a branched condition, and sections of branched limbs of *Lepidosiren* show histological features clearly suggesting a reproduced condition. Budgett and Kerr have noticed a considerable tendency to injury and reproduction of limbs and tail in both these fishes—and there can be no doubt that the reproduction is often bifid. A parallel is therefore afforded with the bifidity sometimes seen in lizards' tails, which in all cases examined are reproduced structures. In some of the latter there is evidence that the extra tail is a new growth arising from an injured place, and in others that the new growth is bifid from its commencement. In the cases of *Lepidosiren* examined the latter condition alone seems to hold.—On the standardisation of anti-venomous serum, by W. Myers. It was shown that Calmette's method was based on views which were no longer tenable; and, further, that a special mixture of snake venoms is required. A more accurate measure of the antitoxin was to test its neutralising power, using ten times the minimal lethal dose of unheated Cobra poison, and mice of 15 grams weight as test animals. With this method it was possible to estimate the serum to within 15 per cent.

Royal Meteorological Society, June 20.—Dr. C. Theodore Williams, President, in the chair.—Mr. W. Marriott read a paper on rainfall in the west and east of England in relation to altitude above sea-level. This was a discussion of the mean monthly and annual rainfall for the ten years 1881-90 at 309 stations which the author had grouped according to the altitude of the stations above sea-level. The western stations were considered to be those which drained to the west, and the eastern stations those which drained to the east of the country. The diagrams exhibited showed that there is a general increase in the annual amount of rain as the altitude increases, and

that the rainfall is considerably greater in the west than in the east. The monthly diagrams brought out prominently some interesting features, among which were (1) that the monthly rainfall in the west is subject to a much greater range than in the east; (2) that in the west the maximum at all altitudes occurs in November, but in the east it is generally in October; (3) that in the west the spring months, April, May and June, are very dry; and (4) that both in the west and east there is a very great increase in the rainfall from June to July.—A paper by Mr. J. Baxendell was also read, giving a description of a new self-recording rain-gauge designed by Mr. F. L. Halliwell, of the Fernley Observatory, Southport. This rain-gauge, which the author believes approaches very closely to an ideal standard, has also the merit of being constructed at a moderate price.

PARIS.

Academy of Sciences, June 18.—M. Maurice Lévy in the chair.—On the monument erected to Lavoisier, by M. Berthelot. The monument is now finished, and will be unveiled on July 27.—The problem of the cooling of the earth's crust treated from Fourier's point of view, but by a much simpler method of integration, by M. J. Boussinesq.—Actinometric observations during the eclipse of May 28, by M. J. Violle. A diagram of the results obtained is given which closely approximates to the theoretical curve, the divergence being mainly due to the lag of the instrument, but also apparently in part owing to an absorption of heat by the solar atmosphere. The minimum ratio deducted from the observations was 0·12, distinctly less than the ratio of the radiant surfaces 0·14. Two sets of observations were carried out, one on the Pic du Midi, at a height of 2860 metres, and the other from a balloon, at a height of about 10,000 metres.—On the formation of nitric acid in the combustion of hydrogen, by M. Berthelot. Hydrogen was burnt from a jet in oxygen containing varying amounts of nitrogen, and also in the calorimetric bomb at pressures of from one to twenty atmospheres, and the amounts of nitric acid formed determined. The proportion of nitric acid formed was greatest in the bomb, and increased with the initial pressure of the gases.—The combustible gases of the atmosphere: the air of towns, by M. Armand Gautier. Air is drawn, after careful purification from dust, moisture and carbon dioxide, over red-hot copper oxide, and the amounts of water and carbonic acid determined. The mean results for twenty-two days was 1·96 mgr of hydrogen and 6·8 mgr. of carbon per 100 litres of air; but these quantities become 3 96 mgr. and 12·45 mgr. respectively when a correction is applied for the incomplete combustion effected by the particular length of copper oxide used.—The last eclipse of the sun and the zodiacal light, by M. Perrotin.—The occultation of Saturn by the moon of June 13 last, by M. Perrotin.—On the formation of beds of stipite, brown coal and lignite, by M. Grand'Eury. In the formation of brown coals marsh plants were the chief factor, trees only occurring rarely.—M. Dwelshauvers-Dery was elected a Correspondent for the Section of Mechanics, and M. D. P. Ehlert a Correspondent for the Section of Mineralogy.—Observations of the total eclipse of the sun of May 28 last, made at Argamasilla, in Spain, by M. H. Deslandres. The work undertaken included the measurement of the velocity of rotation of the corona, and the examination of its ultra-violet spectrum; the study of the ultra-violet spectrum of the reversing layer; the calorific spectrum and the direct photography of the corona.—The partial eclipse of the sun of May 28, at the Observatory of Toulouse, by MM. Montingerand, Rossard and Besson. The results obtained were confined to direct observation of contacts, measurement of the common chord, photographic observations and the knowledge of meteorological phenomena.—The total eclipse of May 28 studied at Elche, by M. J. C. Sola. Photographs of the spectra of the chromosphere and corona were taken.—Observations of the shadow fringes made during the total eclipse of the sun of May 28, by M. Moye.—On the uniform integrals of the problem of n bodies, by M. Paul Painlevé.—On the general theory of rectilinear congruences, by M. A. Demoulin.—On the expansion of fused silica, by M. H. Le Chatelier. The mean coefficient of expansion of fused silica for a temperature range of 0° to 1000° is 0·000,0007, the smallest coefficient known for any common substance.—Action of oxidising agents upon alkaline iodides, by M. E. Péchard. A study of the interaction of alkaline iodides with potassium permanganate, sodium periodate, potassium manganate, ozone and hydrogen peroxide.—Study of the viscosity of sulphur at temperatures above the temperature of maximum viscosity, by M. C. Malus.—On the selenides of iron, by M. Fonzes-Diacon. Several selenides of iron can be prepared of the composition indicated by the formulæ $FeSe_2$, Fe_2Se_3, Fe_3Se_4, Fe_7Se_8, and FeSe. They are attacked by hydrochloric acid with difficulty, $FeSe_2$ being unaffected by this reagent.—The true atomic weight of boron, by M. G. Hinrichs. From two analyses of boron carbide made by M. H. Gautier, the author concludes that the true atomic weight of boron is exactly 11.—Action of sulphur dioxide and hydrogen sulphide upon pyridine, by M. G. André. Sulphur dioxide gives a crystalline compound with pyridine, $C_5H_5N.SO_2$, and the action of suphuretted hydrogen upon this gives pyridine trithionate and tetrathionate.—On the $\alpha\beta$-dimethylglutolactonic acids, by M. E. E. Blaise.—On the reserve carbohydrates in the seed of *Trifolium repens*, by M. H. Hérissey. A mannogalactane was isolated from the seeds of *Trifolium repens*, resembling in its properties the carbohydrates obtained from lucerne and fenugreek.—Presence of iodine in the blood, by MM. E. Gley and P. Bourcet. Iodine was found to be present in the blood of dogs in amounts varying from ·013 mgr. to ·06 mgr. per litre of blood. The iodine is in the liquid portion of the blood existing combined with proteid matter, analogous to the iodine in the thyroid gland.—Reality of urinary toxicity and of autointoxication, by M. A Charrin.—On the anticoagulating power of serum in the pathological state, by MM. Ch. Achard and A. Clerc. Human blood serum, when present in sufficient quantity, prevents the coagulation of milk by rennet, the quantity of rennet solution required to produce coagulation measuring the activity of the serum. The anticoagulating power of the serum is unaffected by many diseases, but in others, such as pneumonia, septicemia with acute nephritis, uterine cancer, and advanced tuberculosis, this power is reduced to one-half or even less.

CAPE TOWN.

South African Philosophical Society, May 2.—L. Péringuey, President, in the chair.—Mr. Sclater exhibited a portion of a bone found at a considerable depth below the surface in Grave Street, and presented to the Museum by Col. Feilden. The bone was obviously the upper portion of the radius and ulna of a large ungulate animal; it appeared to be too large for an ox, and Mr. Sclater suggested that it might perhaps be that of a hippopotamus.—The Rev. Dr. F. C. Kolbe read his paper, entitled "Ultimate analysis of our concept of matter." The lecturer first briefly stated the four prevailing views on the subject—the mechanical, the dynamic, the vortical, and the scholastic or Aristotelian. The first two theories being for various reasons rejected, the lecturer stated that the purpose of this paper was to reconcile the third and fourth.

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